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CHANGES IN GAS EXCHANGE, TISSUE RESPIRATION AND GLYCOLYSIS IN RATS DURING HYPOKINESIA

Translation of "Zminy Hazoobminu, Tkanunnoho Dykhannya ta Hlikolizu u Shchuriv pry Hipokinezii", **Fiziolohichnyy Zhurnal, Vol. 22, No. 3, 1976, pp 414-417**

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16. Abstract

This article presents the results of an experiment which studied changes in oxygen balance under conditions of hypokinesia in rats.

The experimental method used and results obtained are discussed.

In summary, the effect of the stress during hypokinesia is expressed most clearly in the changes of general gas exchange, and in the intensity of liver and myocardial tissue respiration.

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Changes in Gas Echange, Tissue Respiration and Glycolysis In Rats During Hypokinesia

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Extreme restriction of man's kinetic activity causes changes in oxygen balance of the organism, which basically brings about a lowering of oxygen consumption. There are published reports of a decrease in oxygen consumption and basic metabolism of healthy men bedridden for 15-20 days /4, 6, 16/, 70 days /10/, and 120 days /11/. However, there are conflicting reports describing a 57% increase in oxygen consumption of sportsmen's organisms following a 10-day hypokinesia /1/.

The reports of gas exchange studies in animals under condition of experimental hypokinesia are even more conflicting. On one hand, it was observed that a 30-day, and a 60-day restriction of locomotion in rats did not bring about appreciable changes in the overall gas exchange /12, 14/, or blood composition /8/. On the other hand, a 36% /13/, and a 50% /3/ increase in oxygen consumption after a 30-day hypokinesia has been reported.

It follows from the published data that a prolonged hypokinesia causes a change in the organism's metabolism. However, the nature of these alterations needs clarification. The duration of the gas exchange studies in animals varies between 30 and 120 days of hypokinesia in the reports of other authors. However, there is no description of gas exchange dynamics during the first month of restricted mobility.

We have studied oxygen consumption of the entire organism, and also tissue respiration and glycolysis in the myocardium, skeletal muscle and liver of rats 4, 8, 16 and 30 days after the commencement of hypokinesia.

*Numbers in margin indicate pagination of foreign text.

Experimental Methods

Experiments were performed with 233 white, non-inbred rats of both sexes with initial body weight 130-180 g. In order to create conditions of hypokinesia, animals were placed in specially constructed individual cages which drastically reduced locomotive activity. Control rats were kept in the same room, in cages of an ordinary vivarian type. Animals were fed an ordinary rat food. The dynamics of animal body weight was observed.

Oxygen consumption was determined according to the procedure of Kalabukhov /5/ on days 4, 8, 16 and 30 of hypokinesia. The intensity of tissue respiration and glycolysis were studied in the Warburg apparatus at the same intervals.

Results and Discussion

Experiments have demonstrated that wavelike variations occurred in the general gas exchange in the rat during the 30-day hypokinesia. It can be seen in the Table that the mean value of oxygen consumption on day four of restricted mobility increased from the initial value of 0.159 ± 0.0079 L/100 g/hr to 0.186 ± 0.0127 L/100 g/hr ($p = 0.05$) which represents a 16.98% increase. During days 8 and 16 of the experiment, oxygen consumption was somewhat reduced, relative to the initial level, and during day 30 it went up. However, these variations proved not to be significant.

Table. Oxygen consumption (M ± m) by the organism of rats during a 30-day hypokinesia (in L/100 g body weight/hr)

Experimental conditions	Day of Experiment			
	4	8	16	30
Initial values	0.159±0.0079	0.183±0.0097	0.177±0.0161	0.138±0.0123
after Hypokinesia	0.186±0.0127	0.169±0.0114	0.155±0.0198	0.164±0.0094
p	=0.05	>0.05	>0.05	>0.05

Similarly, wavelike but better defined changes in oxygen consumption were found when the intensity of tissue respiration was studied in the individual tissues (Figure 1). The most significant elevation in oxygen consumption from 3.00 ± 0.309 to 4.52 ± 0.295 μL O_2/mg dry tissue/30 min ($p < 0.01$) occurred in the liver during the fourth day of hypokinesia. Later, a tendency for the normalization of liver tissue respiration was observed, with an insignificant increase during day 30. Oxygen consumption increased in the myocardium from 1.96 ± 0.176 to 2.53 ± 0.185 μL O_2/mg dry tissue/30 min ($p < 0.01$) on day 16 of hypokinesia. During day 30 of the experiment, myocardial tissue respiration decreased to values below the initial ones (1.76 ± 0.135 μL O_2/mg dry tissue/30 min; $p > 0.05$). During the initial 16 days of hypokinesia there were insignificant variations of oxygen consumption values for the skeletal muscle. However, a lowering of tissue respiratory intensity from 1.63 ± 0.094 to 1.13 ± 0.106 μL O_2/mg dry tissue/30 min ($p < 0.01$) took place by day 30 of the experiment.

Changes in glycolysis were of a different nature: its intensity was gradually decreasing during hypokinesia in all experimental tissues (Figure 2). A definite decrease in the intensity of glycolysis on day four of the experiment was observed only in the myocardium (from 2.41 ± 0.225 to 1.81 ± 0.100 μL CO_2/mg dry tissue/30 min; $p < 0.02$). Myocardial glycolysis decreased even more to 1.55 ± 0.082 ($p < 0.001$) during day eight, and on day 30 it reached 1.33 ± 0.121 μL CO_2/mg dry tissue/30 min ($p < 0.002$). In the liver and in the skeletal muscle, a definite lowering of glycolitic activity began on day eight of hypokinesia

in agreement with observations of Barbashova /2/, and are another indication of the condition of a harsh stress during this period. Portugalov et al. /15/ have noticed that the endocrine glands of

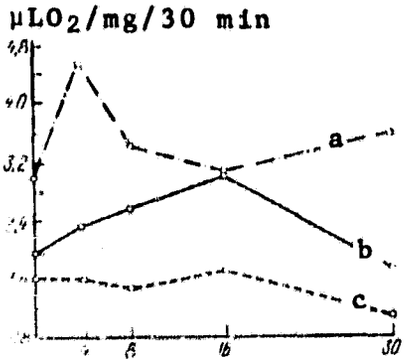

Fig. 1. Changes in the intensity of tissue respiration during a 30-day hypokinesia. Vertical axis, μL O_2/mg dry tissue/30 min; abscissa, days of hypokinesia. a, liver; b, heart; c, skeletal muscle.

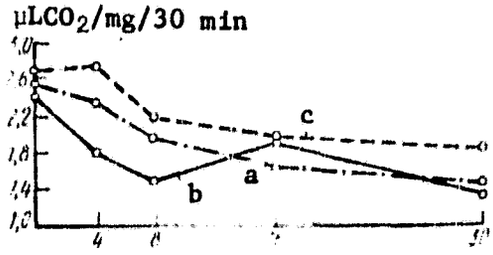

Fig. 2. Changes in the intensity of tissue glycolysis during 30-day hypokinesia. Vertical axis, μL CO_2/mg dry tissue per 30 min. Abscissa, days of hypokinesia.

the organism work with maximal intensity during the first five days, followed by a period of adaptation to the new condition. Kovalenko et al./7/, studying the system adrenal cortex - hypophysis during hypokinesia concluded that changes during the initial period are the result of the emotional tension. Furthermore, the restriction of mobility becomes evident at the end of the second week.

In summary, the effect of the emotional stress during the initial period of hypokinesia is expressed most clearly in the changes of general gas exchange, and in the intensity of liver and myocardial tissue respiration. Changes in the metabolism of the skeletal muscle were of somewhat different nature. There

was no evidence of wavelike alterations: a lowering in the intensity of tissue respiration was detected only on day 30. However, lowered glycolysis was observed in this tissue much earlier, beginning on day eight of hypokinesia.

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